Claims

1. A method of manufacturing a threaded joint for a pipe having a pin portion with a male thread comprising a tapered thread with a thread cross-sectional shape which is roughly trapezoidal, and a box portion having a female thread which engages with the male thread and which comprises a tapered thread with a thread cross-sectional shape which is roughly trapezoidal,

a metal seal portion provided on the pin portion and the box portion,

a torque shoulder portion provided on the end of the pin portion and on a portion of the box portion which abuts therewith,

characterized by determining the dimensions of each portion by:

determining the outer diameter (OD) and the pipe wall thickness (t) of a pipe having the pin portion,

determining the lip inner diameter (D_2) of the pin portion based on the determined pipe outer diameter (OD) and pipe wall thickness (t), and determining the inner diameter (D_1) of the box portion based on the determined lip inner diameter (D_2) of the pin portion,

provisionally determining a lip thickness ratio (X) based on the determined pipe outer diameter (OD) and pipe wall thickness (t), provisionally determining the lip thickness (ℓt) of the pin portion and the lip root outer diameter (DB) of the pin portion based on the provisionally determined lip thickness ratio (X), and determining the thread engagement height (h) and the thread pitch (P) based on the determined pipe outer diameter (OD) and pipe wall thickness (t),

provisionally determining the thread taper (Tt) based on the determined pipe outer diameter (OD) and pipe wall thickness (t), and on the provisionally determined lip outer diameter (DB) of the pin portion, the provisionally determined complete engagement thread length (L) and the determined thread engagement height (h),

determining the lip length (ℓ), the seal length of the pin portion (S_P), the seal taper (Ts), the shoulder angle (θ_1), and the lip thickness ratio (X) based on the provisionally determined lip thickness (ℓt) of the pin portion and the provisionally determined lip root outer diameter (DB) of the pin portion so that a function f is

greater than 1.2,

and thereby determining the shape of the pin lip, and determining the lip thickness (ℓt) of the pin portion and the lip outer diameter (DB) of the pin portion, and also determining the diameter of the end of the lip portion (Papex),

determining the thread taper (Tt) and the complete engagement thread length (L) based on the determined lip thickness (ℓt) of the pin portion, the determined lip root outer diameter (DB) and the determined thread engagement height (h) of the pin portion,

and determining the thread parallel portion diameter (DA) of the box portion, and determining the load flank angle (α), the stabbing flank angle (β), the gap (δ) between the stabbing flanks, and the gap (γ) between the thread crests, and determining the shape of the seal portion including the seal length (S_B) of the box portion based on the seal length (S_P) of the pin portion and the dimensions of each portion of the pin portion.

2. A method of manufacturing a threaded joint for a pipe having a pin portion with a male thread comprising a tapered thread with a thread cross-sectional shape which is roughly trapezoidal, and a box portion having a female thread which engages with the male thread and which comprises a tapered thread with a thread cross-sectional shape which is roughly trapezoidal,

a metal seal portion provided on the pin portion and the box portion,

a torque shoulder portion provided on the end of the pin and on a portion of the box portion which abuts therewith,

characterized by determining the dimensions of each portion by performing the following Step 1 through Step 5:

Step 1:

Determining the outer diameter (OD) and the pipe wall thickness (t) of a pipe having the pin portion, and determining a thread pitch (P) based on the determined pipe outer diameter (OD) and pipe wall thickness (t).

Step 2:

Provisionally determining the completed engaged thread length (L) of the pin portion and the box portion based on the determined pipe outer diameter (OD) and pipe wall thickness (t),

in the below-described Third Step, provisionally determining the lip thickness ratio (X) based on the determined pipe outer diameter (OD) and pipe wall thickness (t), and provisionally determining the lip thickness (ℓt) of the pin portion and the lip root outer diameter (DB) of the pin portion based on the provisionally determined lip thickness ratio (X), and

provisionally determining the thread taper (Tt) based on the determined pipe outer diameter (OD) and pipe wall thickness (t), the provisionally determined complete engagement thread length (L) and the provisionally determined lip root outer diameter (DB) of the pin portion.

Step 3:

Determining the lip inner diameter (D_2) of the pin portion based on the determined pipe outer diameter (OD) and pipe wall thickness (t), and determining the inner diameter (D_1) of the box portion based on the determined lip inner diameter (D_2) of the pin portion,

determining the shape of the pin lip by provisionally determining the lip length (ℓ), the seal length (S_P) of the pin portion, the seal taper (Ts), the shoulder angle (θ_1), and the lip thickness ratio (X) based on the provisionally determined lip thickness (ℓt) and lip outer diameter (DB) of the pin portion so that the function f is greater than 1.2, and based on the determined pin lip shape,

(i) determining the lip thickness (ℓt) of the pin portion and the lip root outer diameter (DB) of the pin portion, determining the thread parallel portion diameter (DA) of the box portion based on the lip thickness (ℓt) and the lip root outer diameter (DB) of the pin portion, and determining the thread taper (Tt) and the complete engagement thread length (L), and

(ii) determining the shape of the seal portion including the seal length (S_B) of the box portion and the diameter of the end of the seal (Bapex) of the box portion

based on the dimensions of each portion of the seal portion of the pin portion.

Step 4:

Determining the thread engagement height (h) based on the determined pipe outer diameter (OD) and pipe wall thickness (t), determining the pitch diameter (Dp) based on the thread engagement height (h), and based on the pitch diameter (Dp):

(i) determining the box portion outer diameter (W) and the location of the pitch diameter (LPt) of the pin portion,

(ii) determining the thread interference amount (It), and

(iii) determining the shoulder depth (LB) of the box portion and the shoulder length (IRes) of the box portion, and determining the overall length (NL) of the box portion based on the shoulder depth (LB) of the box portion and the shoulder length (IRes) of the box portion.

Step 5:

Determining the load flank angle (α), the stabbing flank angle (β), the gap (δ) between the stabbing flanks, and the gap (γ) between the thread crests based on the determined pipe outer diameter (OD), the pipe wall thickness (t), the thread engagement height (h), and the thread pitch (P).

3. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the allowable range for the complete engagement thread length (L) of the pin portion and the box portion is at least 3 times the pipe wall thickness when {pipe wall thickness (t)/pipe outer diameter (OD)} is at least 0.096, it is at least 4 times the pipe wall thickness when {pipe wall thickness (t)/pipe outer diameter (OD)} is at least 0.084, it is at least 5 times the pipe wall thickness when {pipe wall thickness (t)/pipe outer diameter (OD)} is at least 0.052, it is at least 5 times the pipe wall thickness when {pipe wall thickness (t)/pipe outer diameter (OD)} is less than 0.052, and the lip inner diameter (D_2) of the pin portion is less than or equal to pipe inner diameter (D_1).

4. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the lip thickness (ℓt) of the pin portion is found by the following Equation 5:

$$\ell t = X \bullet (t/OD) \bullet D_2/\{1 - 2 \bullet X(t/OD)\} \ldots . (5)$$

5. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the thread engagement height (h) is determined based on the pipe outer diameter (OD) or the pipe outer diameter (OD) and pipe wall thickness (t).

6. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the thread taper (Tt) is found by the following Equation 7:

$$1/Tt = (OD - DB - 2c - 2h - 2\epsilon)/L \ldots (7)$$

wherein c is 1/2 of the difference between the thread root diameter and the lip outer diameter of the pin portion at the location of the lip root of the pin portion, and ϵ is the difference in the radius of the thread crest portion and the thread bevel top portion at the location of the lip root.

7. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the complete engagement thread length (L) is found by the following Equation 8.

$$L = (OD - DB - 2c - 2h - 2\epsilon) \bullet Tt \ldots (8)$$

8. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the function f is found from the following Equation 9:

$$f = -3.26 \times 10^{-1} + 3.19 \times 10^{-2}(\theta_1) + 1.43(X) - 4.67 \times 10^{-4}(\ell) + 8.39 \times 10^{-2}(S_P) - 6.22 \times 10^{-1}(Ts) \quad \ldots (9)$$

wherein $5° \leq \theta_1 \leq 20°$, $0.52 \leq X \leq 0.75$, $6 \text{ mm} \leq \ell \leq 30 \text{ mm}$, $3 \text{ mm} \leq S_P \leq 10 \text{ mm}$, and $1 \leq Ts \leq 16$.

9. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the stabbing flank angle β is found from the following Equation 11:

$$\beta \leq \tan^{-1}\left[\frac{\gamma\tan(\alpha)}{\delta\tan(\alpha) - \gamma}\right] \quad \ldots \quad (11)$$

wherein $0° > \alpha > -20°$, γ is an extremely small value, $25° < \beta < 45°$, and δ is an extremely small positive value within a range which the worker can handle taking into consideration costs and performance.

10. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the thread pitch (P) is determined based on the pipe outer diameter (OD) or the pipe outer diameter (OD) and pipe wall thickness (t).

11. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein when $S_B > S_P$, $S_B > S_P + 2.0$ and is found by the following Equation 12, and when $S_B \leq S_P$, it is found by the following Equation 13:

$$S_B > Is \bullet Ts + S_P + R_4 \bullet \tan[90 - 1/2\{90 + \tan^{-1}[1/(2Ts)] + \theta_5\}] \bullet \cos\{\tan^{-1}[1/(2Ts)]\} \quad \ldots (12)$$

$$Ps - \cos\{\tan^{-1}[1/(2Ts)]\} \bullet [R_1 \bullet \tan[90 - 1/2\{180 - \tan^{-1}[1/(2Ts)] + \tan^{-1}[1/(2T_D)]\}] + R_4 \bullet \tan[90 - 1/2\{90 - \tan^{-1}[1/(2Ts) + \theta_5]\}] \geq S_B \geq Is \bullet Ts + \cos[\tan^{-1}\{1/(2Ts)\}] \bullet [R_2 \bullet \tan[90 - 1/2\{90 + \tan^{-1}[1/(2Ts)] - \theta_1\}] + R_4 \bullet \tan[90 - 1/2\{90 - \tan^{-1}[1/(2Ts)] + \theta_5\}]] \quad \ldots (13)$$

wherein Is indicates the seal interference amount, T_D indicates the taper of the pin lip tapered portion, and θ_5 indicates the opening angle of the box seal portion.

12. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the pitch diameter Dp is found by the following Equation 14:

$$Dp = (OD + \mu) - h \quad \ldots (14)$$

wherein μ is a constant which is set based on the outer diameter (OD) of the pipe.

13. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the thread interference amount It is determined by the following Equations 16 or 17, wherein of the values calculated over the entire length by Equation 12 or Equation 13, the smallest value is made the upper limit of the thread interference amount It, and 5% of the upper limit is made the lower limit of the thread interference amount It:

$$It = \frac{\delta y \cdot La^2 \cdot (1 + DI^2/La^2 + dp^2/Lb^2)}{E \cdot dp} \quad \ldots . (16)$$

$$It = \frac{2 \cdot \delta y \cdot Lb^2 \cdot dp \cdot (1 + DI^2/La^2 + dp^2/Lb^2)}{E \cdot (W^2 + dp^2)} \quad \ldots . (17)$$

wherein δy indicates the yield strength (MPa) of the material, E indicates the Young's modulus (MPa) of the joint material, W indicates the box outer diameter (mm), DI indicates the inner diameter (mm) of the pin, dp indicates the pitch circle diameter (mm) of the thread, La^2 indicates (dp^2 - DI^2), and Lb^2 indicates (W^2 - dp^2).

14. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the shoulder depth LB of the box portion is found from the following Equation 18:

$$LB = \ell + L + (h + c)/\{(1/\tan(\theta_1)) - (1/2Tt)\} + 2\bullet(h+2\gamma)\bullet Tt + (h + 2\gamma)/\{\tan(\theta_4) - 1/(2\bullet Tt)\} \quad \ldots (18)$$

wherein θ_4 is the angle of the inner bevel of the end surface of the box portion.

15. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the diameter Bapex of the end of the seal of the box portion is found by the following Equation 23:

$$Bapex = Papex - Is \quad \ldots (23)$$

wherein Is indicates the amount of seal interference.

16. A method of manufacturing a threaded joint for a pipe as set forth in claim 1 wherein the pipe is an oil well pipe.